APPENDIX C.1

TONGASS FISH HABITAT OBJECTIVES

Appendix 1. TONGASS FISH HABITAT OBJECTIVES

INTRODUCTION

The numerous watersheds on the Tongass National Forest provide spawning and rearing habitats for most of the fish produced in Southeast Alaska and support major subsistence, commercial, and sport fisheries. Maintaining this habitat and associated high-quality water is a focal point of public, state, and Federal natural-resource agencies, as well as user groups, Native organizations, and individuals.

The concept of fish habitat objectives has been developed to concisely measure and describe desired physical and biological conditions for fish habitat. This concept of defining measurable objectives for stream, riparian, and watershed condition, and describing what is "good" fish habitat, is a key component of the interagency (Forest Service, Bureau of Land Management) Pacific Salmon Conservation Strategy (PACFISH) (FEMAT 1993). These habitat objectives also provide the criteria for determining attainment or progress toward goals of maintaining and restoring riparian and aquatic habitat for Pacific salmon.

Fish habitat objectives are useful tools for assessing how effective management procedures are for maintaining diverse, high-quality fish habitat. The Alaska Region-PNW Research Station Anadromous Fish Habitat Assessment Plan (1994) provided direction for developing and using these habitat objectives for Alaska. The Fish Habitat Assessment Team developed these objectives by using the proposed PACFISH objectives as a reference base to identify the attributes that need to be maintained and monitored to protect fish habitat quality. The interim objectives for the Tongass should be viewed as benchmarks that are used to objectively assess or measure fish habitat condition and not management goals that are always attainable. The habitat objectives are a first approximation of scientifically based indicators of healthy, fully functioning aquatic systems on the Tongass National Forest. Information and the rationale for refining the proposed PACFISH objectives to fit the Tongass National Forest, documented below, are based on localized aquatic habitat information.

The general process we used to develop Tongass-specific objectives was as follows: We first developed general categories of key habitat attributes from which the riparian habitat objectives for Alaska could be derived. These key attributes included large woody debris, stream substrate composition, channel morphology, off-channel flood plain habitat, salmonid distribution and density, and sediment source from mass wasting. This initial list was evaluated over a 2-month period to determine what information in existing stream-survey data bases could be used to develop interim objectives for Alaska. Issues relevant to the use of these attributes were resolved, as follows, in the 31 March 1994 Team meeting in Juneau:

Large woody debris--The size and frequency of large woody debris pieces in the stream channel is a key habitat attribute that could readily be derived for Alaska streams (Bryant 1983, Bryant 1984, Lisle 1986, Robison and Beschta 1990). We decided to use total pieces of large debris per unit area of active stream channel, and stratified by channel type or channel process group as a draft objective, which may be modified later to include size-class distributions for specific channel types. Channel types describe discrete stream segments having consistent stream channel and riparian characteristics. Process groups describe groups of channel types that were formed and are influenced by similar geomorphic processes (see table 1-A for a more complete description of the stream classification).

Off-channel habitats--Off-channel habitat consists of side-channels and sloughs that are connected to mainstem flood-plain channel types during high-flow events. Small footslope tributaries fed by shallow alluvial aquifers may also be defined as providing off-channel habitat for salmonids. The amount and condition of these refuge habitats were recognized as a key barometer of habitat diversity and productivity in many Southeast Alaska and British Columbia watersheds (Murphy and others 1984, Hartman and Brown 1987, Bryant and Sedell in press). Determining acres of off-channel habitat is difficult without extensive field traverses through flood-plain riparian areas. Such habitat will be integral to the design of Riparian Habitat Conservation Areas but will not be used as a management objective.

Substrate Composition--Available spawning area is often used on the Tongass as a key indicator of salmonid production potential (USDA Forest Service 1981). Review of stream-survey data showed very high variability in spawning area data that is believed to be a function of observer bias. Substrate size distribution by channel type as determined by Wolman pebble count (Wolman 1954) was a much more precise measure to assess substrate condition and habitat relations.

Channel morphology--Measures of pool frequency and bankfull channel width-to-depth ratio were selected as habitat objectives. These attributes were measured fairly consistently by stream survey crews and are generally recognized to be useful indices of habitat condition and channel stability (MacDonald et al 1991, FEMAT 1993, Overton et al 1993).

Distribution and density of salmonids--This criterion was dropped from consideration as a quantifiable management objective because of high natural variability in fish populations between watersheds and the cyclic nature of salmonid populations. These data are recognized as valuable for evaluating long-term trends in riparian ecosystem condition, however (Sedell et al. 1990, Sedell and Reeves 1991). Snorkeling surveys to measure species distribution and relative densities of salmonids are recommended to supplement riparian habitat objectives in assessing fish habitat condition.

Slope stability--Sediment delivery from mass-wasting events is a major disturbance factor that affects channel stability and fish habitat condition in Southeast Alaska and coastal British Columbia (Sidle 1980; Hogan 1986, 1987, 1989; Swanston 1991; Swanston and Marion 1991; Swanston and Erhardt 1993). No management objective for mass wasting has been specified, however, because of high variability in mass-wasting frequency and sediment-delivery rates to streams, and a general lack of comprehensive inventory, monitoring, and research data on the long-term influence of mass-wasting events on channel stability and fish habitat condition. A qualitative mass wasting/sediment delivery risk assessment will be done for the three pilot watershed analyses. (See also the discussion of watershed analysis results, appendix 3 of this report.)

After the range of habitat objectives was narrowed, we conducted a comprehensive analysis of stream survey data. Data from pristine watersheds were used in the analysis to assure that data represented only natural variability in riparian and stream habitat condition. Two main sources of stream survey data were used: channel type mapping verification surveys conducted during the late 1980s and more recent basin-wide fish habitat surveys. The data represent a wide range of watersheds scattered throughout the Tongass National Forest (see maps, figs. 1A, 1B). Rationale and methodology for analysis of these data are presented in the methods section below.

METHODS

The first step in data compilation was to link habitat survey information with specific channel type map segments to assign the data to meaningful strata for analysis. The channel type stream classification framework adopted in the Alaska Region (Paustian 1992) categorizes stream segments with similar morphology that are influenced by similar fluvial and riparian processes (table 1A). This stratification approach reduces the variability for many habitat attributes when characteristics of stream segments are compared within a watershed or between watersheds.

Figure 1A--Watersheds used to describe natural Tongass fish habitat (basin-wide survey watersheds only, by value comparison unit)

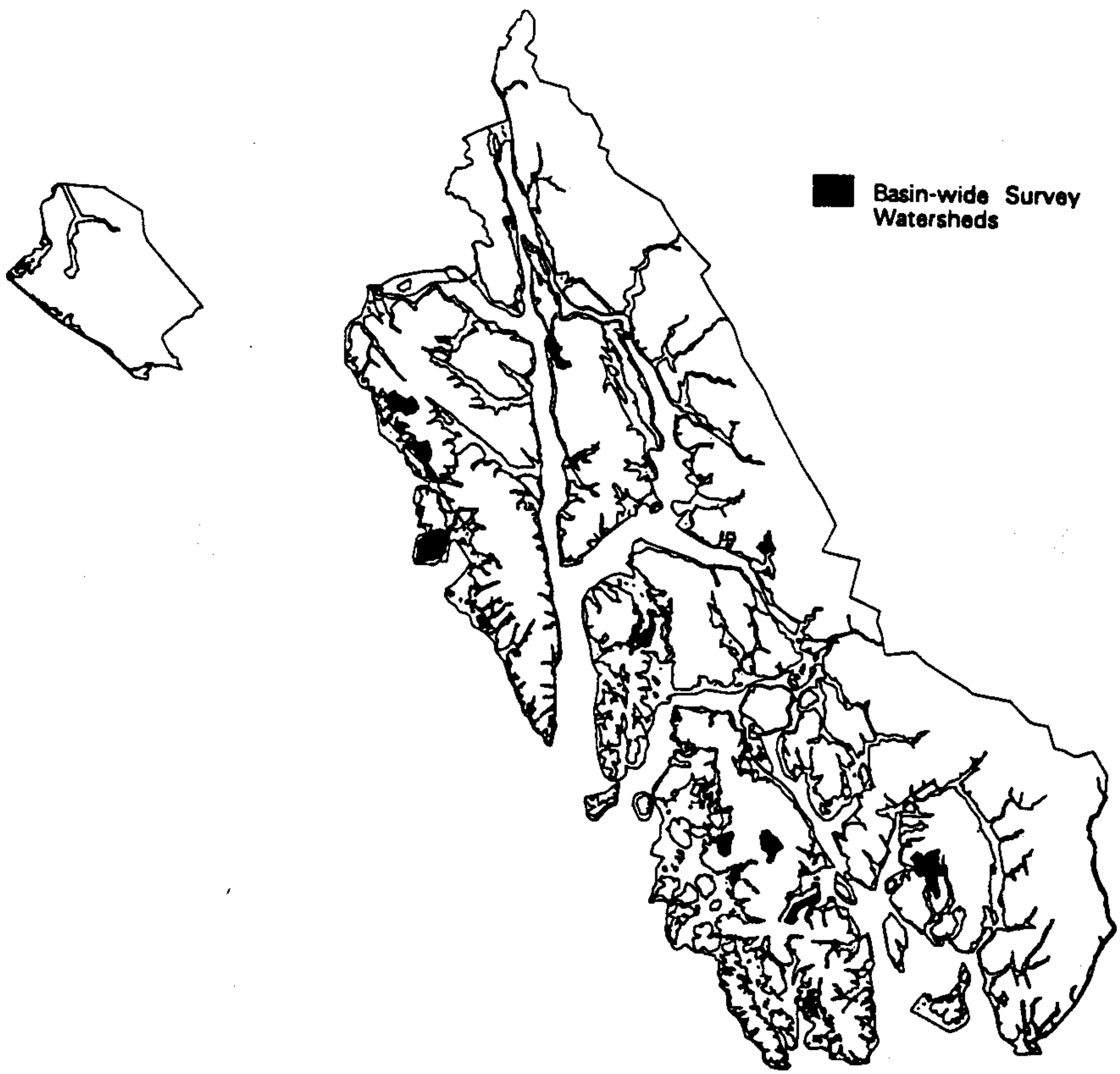
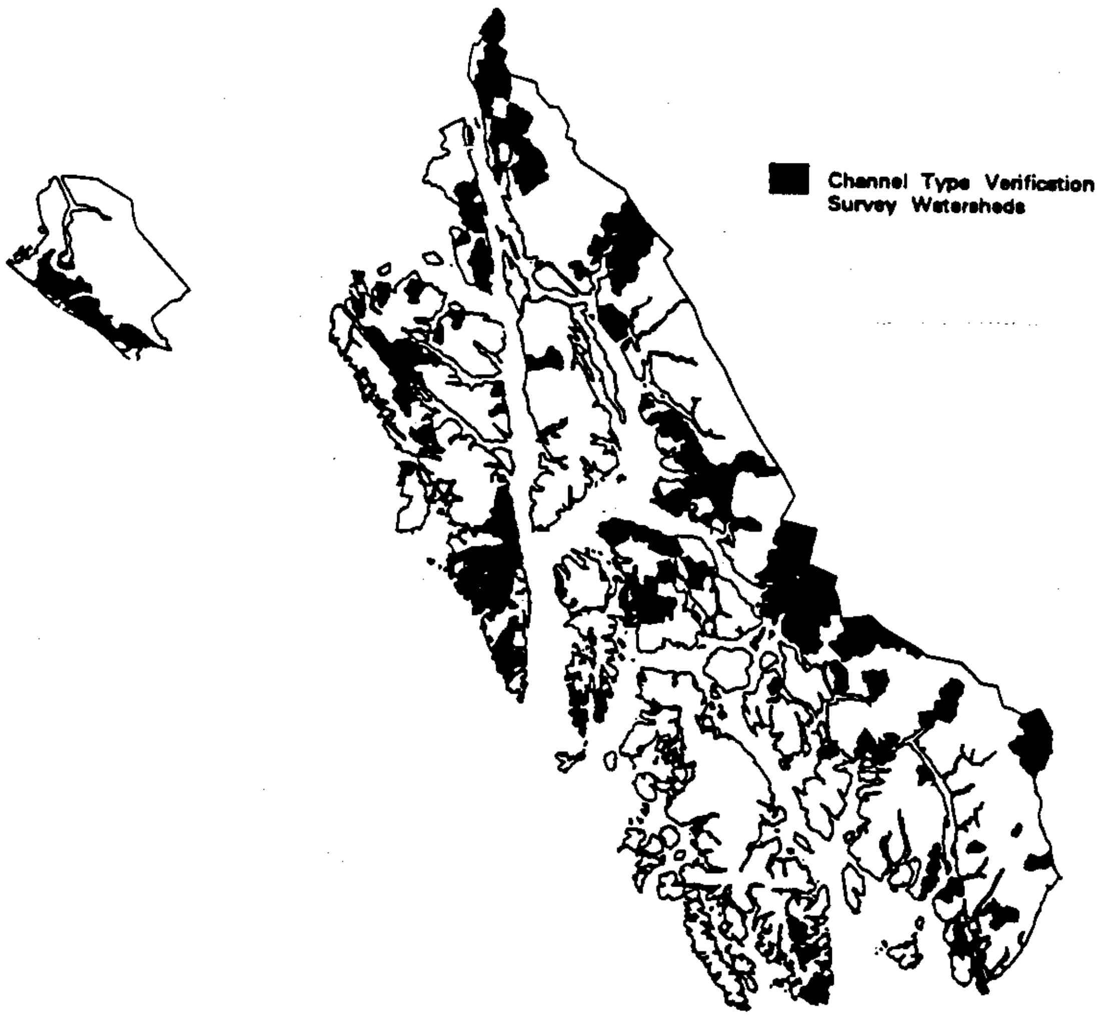


Figure 1B--Watersheds used to describe natural Tongass fish habitat (channel-type verification survey watersheds only, by value comparison unit)



All known data sets pertaining to stream channel conditions on the Tongass were considered for inclusion in the analysis. Three primary sources of data were initially identified: Barber and Oswood Level IV surveys (USDA Forest Service 1981); channel-type verification surveys (Paustian 1992); and basin-wide stream surveys (Dolloff et al. 1993). The Barber and Oswood surveys were excluded because the data were not in an electronic format, and the survey segments could not readily be linked to channel-type map segments. Some useful information may yet be obtained from these surveys. Channel-type verification surveys and basin-wide stream surveys were selected as the most thorough, accurate, and accessible sources of data. Note, however, that these data were not explicitly intended for use in developing fish habitat objectives. These two types of surveys were conducted by using different methodologies, so the data sets used in this analysis are treated as independent measures of the same stream conditions.

A brief description of the two survey methodologies is provided, followed by an explanation of the methods used to compile and analyze the data. Channel-type verification surveys were initiated in the early 1980s as a way to classify and catalog different types of streams, and as a method of verifying the accuracy of stream classification that had been determined initially from aerial photos. The data were collected and compiled primarily by the Chatham Area Supervisor's Office, which resulted in a survey protocol that was well defined and applied consistently to a large number of streams. The data includes sample sites in 159 watersheds with a wide geographic distribution across the Tongass (fig. 1B). Care should be taken in applying these data for certain habitat indices because channel-type surveys only required taking measurements on a very short, "representative" length of stream (about 100 meters). Using measurements from a short segment of stream to estimate general conditions throughout the stream can lead to serious misinterpretation (Hankin 1986, Overton 1993). Pool and woody debris data are particularly sensitive to this problem because they are seldom evenly distributed within a stream. Measurements taken on a small section of stream will often equal zero or a very high number. If many small sections are surveyed, the average will eventually begin to approximate existing conditions. The range, standard deviation, and variance for these attributes will always be high, which will limit their usefulness. The most valuable aspects of this data set are the consistency of measurements and the high number of streams surveyed.

Basin-wide stream surveys on the Tongass began a decade later (1990 to 1993). These data were collected by many different Ranger Districts, and the PNW Research Station did not follow a standardized methodology. Basic survey protocols were frequently adapted to accommodate different survey objectives. Other limitations of the basin-wide survey data are small sample sizes for all channel-type strata and limited geographic coverage across the Tongass. The data set is from about 15 watersheds widely distributed across the Tongass including Black River, Goon Dip River, Rio Roberts Creek, Slippery Creek, Shaheen Creek, Wheeler Creek, Aha Creek, Salt Creek and Old Franks Creek. (Complete information on stream survey data can be obtained from Cal Casipit, Alaska Region Fisheries Program Manager, USDA Forest Service, Juneau, AK.) Compared to the channel-type surveys, the basin-wide stream data contain a broader range of attributes measured much less consistently. Basin-wide surveys covered longer stream segments (ranging from 200 meters to several kilometers). This data set is useful because it contains more-detailed information on pools and woody debris.

Both of these data sets contained surveys from highly altered watersheds as well as from pristine ones. Before any analysis was performed, streams in watersheds affected by commercial timber harvest were deleted from the data base. To determine which surveys were conducted in altered areas, GIS was used to create a list of harvested acreage by value-comparison unit watershed (see the Tongass Land Management Plan 1979). If a unit contained any timber harvest at the time of the survey, it was eliminated from the data set. No similar list of road locations was generated, but it was assumed that streams in unharvested value-comparison units should have minimal likelihood of road-related alteration.

Table 1A--Summary of stream process-group characteristics for Alaska Region channel-type classification (Paustian 1992).

Process-group name [1] / Criteria	Glacial outwash (GO)	Palustrine (PA)	Flood plain (FP)	Alluvial fan (AF)	Large, contained (LC)	Moderate-gradient, mixed control (MM)	Moderate-gradient, contained (MC)	High-gradient, contained (HC)
Landform [2]	Glacial river flood plain	Lowland/ wetlands	Flood plain	Alluvial fan/cone	Canyon or en-trenched in lowlands	Footslope/ narrow valleys	Entrenched in hills or lowlands	Mountain slope
Stream confinement [2]	>2 x channel width	>2 x channel width	>2 x channel width	>2 x channel width	<1.5 x channel width	1 to 2 x channel width	<1 x channel width	<1 x channel width
Segment slope [2]	<3%	<1%	0.5 to 2%	<5%	1 to 3%	2 to 6%	2 to 6%	>6%
Channel pattern	Braided or multi-branch	Single thread	Single thread or multibranch	Multibranch	Single thread	Single thread or multibranch	Single thread	Single thread
Sinuosity	Meandering	Sinuous	Meandering	Meandering	Straight	Straight or me-andering	Straight	Straight
Stream order	3 to 8	2 to 4	3 to 5	1 to 3	3 to 5	2 to 3	1 to 2	1 to 2
Water source	Glacial melt-water	Peatland runoff	Mountain slope source area runoff dominates in these stream segments; groundwater discharge is also significant in flood plain and alluvial fan segments					
Sediment regimen	Deposition	Storage	Balanced or deposition	Deposition	Balanced	Balanced	Erosive	Erosive
Substrate	Sand/gravel/. cobble	Gravel/sand/ organics	Sand/gravel/ cobble	Gravel/cobble	Gravel/cobble/ boulder	Gravel/cobble/ boulder	Cobble/boulder/ bedrock	Cobble/boulder/ bedrock

[1] Estuarine process group is not included. These process-group categories were developed for the Pacific Gulf Coastal Forest-Meadows Ecoregion. (McNab, W.A., and R. B. Bailey, eds. 1994. *Ecoregions and Subregions of the United States*. [map]. United States. U.S. Department of Agriculture, Washington, DC.).

[2] Primary defining criteria for process-group stream segments.

The channel-type verification data were stratified by channel type and then examined separately by using SAS (Littell et al. 1991). Descriptive statistics (mean, median, mode, variance, coefficient of variation, percentiles, range, and frequency distributions) were generated for the following attributes (also in table 1B): bankfull width / bankfull depth, number of pools per kilometer of survey, number of pieces of large woody debris per kilometer, percentage of pools containing large woody debris, and percentage coverage of bed-substrate size-classes. Because of small sample sizes in some channel types, data from similar channel types were occasionally pooled by process-group categories.

Basin-wide survey data were analyzed identically, but the attributes provided by these surveys were slightly different (table 1B). Some pooling of similar channel types was again necessary to provide adequate sample sizes. Note that no data were pooled across either survey type although some attributes such as large woody debris and pool frequency were common to both surveys. These two sets of measurements are not directly comparable because channel lengths were not consistently determined in the basin-wide surveys, and length measurements were determined differently in the channel-type data set. These two data sets were kept separate throughout the analysis and are displayed separately in graphs, charts, and tables.

Table 1B--Stream habitat variables analyzed by survey type.

Channel-type survey variables	Basin-wide survey variables
Large woody debris/kilometer	Large woody debris/kilometer
Pools/kilometer	Pools/kilometer
Pools/reach	Pool area (% of total)
Bankfull width-to-depth ratio	Pool/riffle ratio
Pools with large wood, %	Large woody debris/1,000 m^2
Substrate size class, %	Dominant cover type
	Dominant substrate

Total area of habitat surveyed was calculated by using all habitat types, including backwater, eddies, and off-channel habitat. Area of pools was calculated by summing the areas of all units identified as pools, including backwater, eddy, and off-channel units. Large woody debris frequency was calculated by unit area (large woody debris/1,000 m^2) based on total area of habitat types in a channel-type segment as described above. Large wood and pool attributes that were calculated on the basis of channel length were dropped from the final analyses because of problems in accurately determining stream segment lengths from the basin-wide survey records. Some aspects of the basin-wide data were difficult to interpret, and although we tried to contact the people who conducted the surveys, we could not always locate them. Data on substrate and large wood size-classes were not used in the final results because of uncertainties and inconsistencies in measurement standards.

RESULTS

Fish habitat objectives are expressed as a range of values based on the 25th, 50th (median), and 75th percentiles for a given channel type or process group, rather than a single value as was used in the interim PACFISH objectives. This approach can better account for the natural range of conditions attributable to differences in watershed physiography, geology, and climate. In addition to regional variability, local disturbances including floods, windstorms, and mass-wasting events contribute to high natural variability in riparian and stream habitat conditions. We selected a range of values between the 25th and 75th percentiles, for selected channel types and process-group categories, as conservative indices of fish habitat condition for the Tongass National Forest. Objectives for width-to-depth ratio were derived from the channel-type data base. Fish habitat objectives for pools and large woody debris were developed from the basin-wide data base. These attributes were determined by the Team to be the most useful indices to evaluate stream habitat conditions given the high natural variability in stream habitat attributes and limitations of the stream survey measurements. Results of the analysis of stream-survey data for selected habitat-objective attributes are summarized in table 1C.

The following set of figures displays the 25th to 75th percentile ranges for several of the habitat attributes analyzed. The key attributes for meeting riparian habitat management objectives are explained in detail below:

Pool Area

Pool area (fig. 1C) is expressed as a percentage of total habitat area, for the 25th to 75th percentile range by process group. Pool area is used rather than pool frequency because of the difficulty of scaling individual pool units and problems with determining consistent stream segment length from basin-wide survey data. Pools are defined as the portion of a stream with lower surface current velocity and greater depth compared to other portions of the stream. Changes in the amount of pool units can indicate shifts in the balance between sediment input and transport associated with change in fluvial erosion or stream-flow regime. Pools may be correlated with channel roughness elements including pieces of large woody debris. Pools are also very important fish habitat features that provide habitat for rearing juveniles, cover for adults, and optimal spawning sites at pool tail-outs. Changes in pool area, which most likely reflect long-term changes in habitat condition, can be an indicator of cumulative watershed effects.

Large Woody Debris

Frequency of large wood pieces per unit area (1,000 m^2) of stream, by channel type and process group for the 25th to 75th percentile range are shown in figure 1D. Unit area rather than unit length of channel was selected for a reference measure because of problems in determining accurate stream-segment lengths from basin-wide survey data. Large woody debris is defined as woody material greater than 10 cm in diameter and 1 m long, that protrude into the active stream channel area. Large woody debris, an indicator of riparian community structure and health, is a key factor influencing aquatic habitat diversity and productivity. Large woody debris is critical in many streams for maintaining habitat cover and complexity for salmonids as well as for aquatic invertebrates that provide an important food source for fish. Large woody debris structure, recruitment, and depletion can be greatly influenced by management activities. Large woody debris is also a good indicator of both short-term and long-term effects of riparian management activities.

Width-to-Depth Ratio

Bankfull channel width-to-depth values for alluvial channel types (floodplain (FP) and moderate gradient, mixed control (MM)), are shown for the 25th to 75th percentile range (fig. 1E). Bankfull stream stage is roughly equivalent to the stream level for a 2-year return-interval flood. Width-to-depth ratio is a general index of channel stability in alluvial channels, predominantly streams in the flood plain and moderate-gradient, mixed-control process-group channels. Channel segments with

Table 1C--Tongass fish habitat objectives.[1]

Habitat objective	Channel type or process group[1]	Interim Tongass habitat standards (percentiles)			Sample size
		25th	50th	75th	
Large woody debris, (pieces/1,000 m²)	FP3	10	32	54	11
	FP4	8	24	34	11
	FP5	4	5	6	3
	HC	16	35	65	4
	LC & MC	6	15	22	22
	MM1	27	45	82	7
	MM2	33	35	44	5
Pool area,%	FP	27	49	61	37
	HC	14	26	40	8
	LC	8	20	27	12
	MC	11	22	39	19
	MM	20	35	52	15
	FP3	20	53	76	15
	FP4	35	47	59	17
	FP5	47	51	60	5
	MM1	28	40	52	13
	MM2	2	22	39	7
Stream width-to-depth ratio, (dimensionless)	FP3	8	13	18	67
	FP4	16	25	35	62
	FP5	30	45	70	70
	MM1	9	12	18	52
	MM2	17	24	33	25

[1] Alpha codes define stream process group (see table 1A). Channel types listed include: FP3, small flood plain; FP4, medium flood plain; FP5, large flood plain; MM1, small, moderate gradient, unconstrained; and MM2, medium, moderate gradient, unconstrained.

consistently high width-to-depth ratios indicate increased sediment storage and aggradation. Sediment aggradation in alluvial channels can be correlated to reduced flow depths, loss of pool area and volume, de-watering of spawning habitat, and loss of macroinvertebrate habitat. Other indirect effects may include changes in stream temperature ranges and increased formation of anchor ice in winter.

Additional Habitat Condition Attributes Assessed

The remaining figures display data summaries for several other stream-survey attributes that should be used as supplemental habitat information to aid in interpreting stream-survey data for watershed analysis. These supplemental results include substrate size distributions for alluvial channel types (fig. 1F), large woody debris size-class distributions (fig. 1G), and fish habitat cover-type composition (fig. 1H) for undeveloped watersheds sampled in the channel-type verification and basin-wide stream survey.

Through further inventory and data analysis, we anticipate that some of these attributes or additional attributes will be used to modify or expand the draft fish habitat objectives presented above (see the following recommendations section).

DISCUSSION

Several important caveats applying to use of these interim fish habitat objectives should be acknowledged. First, deriving specific quantitative objectives for riparian habitat is difficult, in large part because of the wide range in natural variability in habitat attributes and the complex interactions between attributes. Second, habitat attributes must be viewed collectively at a broad watershed scale to be most relevant. Third, riparian habitat objectives should not be used as a specific threshold or fixed target to manage toward. For example, watersheds managed to meet the minimum habitat objectives may not have adequate habitat diversity to buffer against extreme natural events such as floods. Conversely, resources should not be expended to improve some low-productivity habitats if natural processes will defeat these efforts over the long term.

Data Limitations

Several important limitations in the data used to develop the fish habitat objectives were identified in the course of the analysis. These include high natural variability within and among undisturbed streams in Southeast Alaska, small sample sizes for many habitat attributes by channel-type strata, the highly subjective nature of the stream surveys and diversity of experience and training of the field crews who collected these data (low reproducibility of results), and differences in the objectives of the various crews when conducting these surveys.

First, high natural variability among the streams of Southeast Alaska make detecting significant changes or deviations from the norm very difficult, even if these differences do exist. Power analysis is a means of estimating the probability of being able to detect a significant difference when a difference actually exists. The power of a test is computed directly from sample size, variance, and magnitude of difference between the groups being compared. Peterman (1990) suggests that when a test is performed to determine whether a significant difference exists and the results indicate no difference, a power analysis should be performed to determine what the probability was of detecting a difference if it really existed in nature, and the magnitude of the difference that must exist for the test to detect a difference. The power analysis can also be used to determine what sample size would be necessary to achieve a specific power of analysis.

We conducted a power analysis on basin-wide data for large woody debris/1,000 m^2 in a FP3 channel type. Given the sample variance with a significance level of 0.10, a sample size of 36 stream segments is needed to have a 75% chance of detecting a difference of the magnitude 22 pieces of large woody debris/1,000 m^2. This mathematical exercise illustrates that achieving a fairly high certainty when estimating characteristics of an attribute and testing for differences is possible; the degree of certainty, however, depends entirely on variance, sample size, and magnitude of difference.

Second, small sample size was a common limitation of the basin-wide data. As illustrated above, a large sample size can increase the probability of drawing correct conclusions from the analysis. When dealing with a small number of samples, obtaining a very precise approximation of mean values is not possible. For example, the FP5 channel-type woody debris, basin-wide survey data were only measured in three sections of stream, for a total length of about 6 km. In short, given the hundreds of kilometers of FP5 stream in Southeast Alaska, this sample is not adequate for representing a normal range of large woody debris accumulation. We speculate that this inadequacy is particularly true for the high end of the large woody debris distribution in FP5 streams.

Figure 1C--Tongass pool-area habitat objectives, by stream process group from basin-wide survey data (25th, 50th, 75th percentiles)

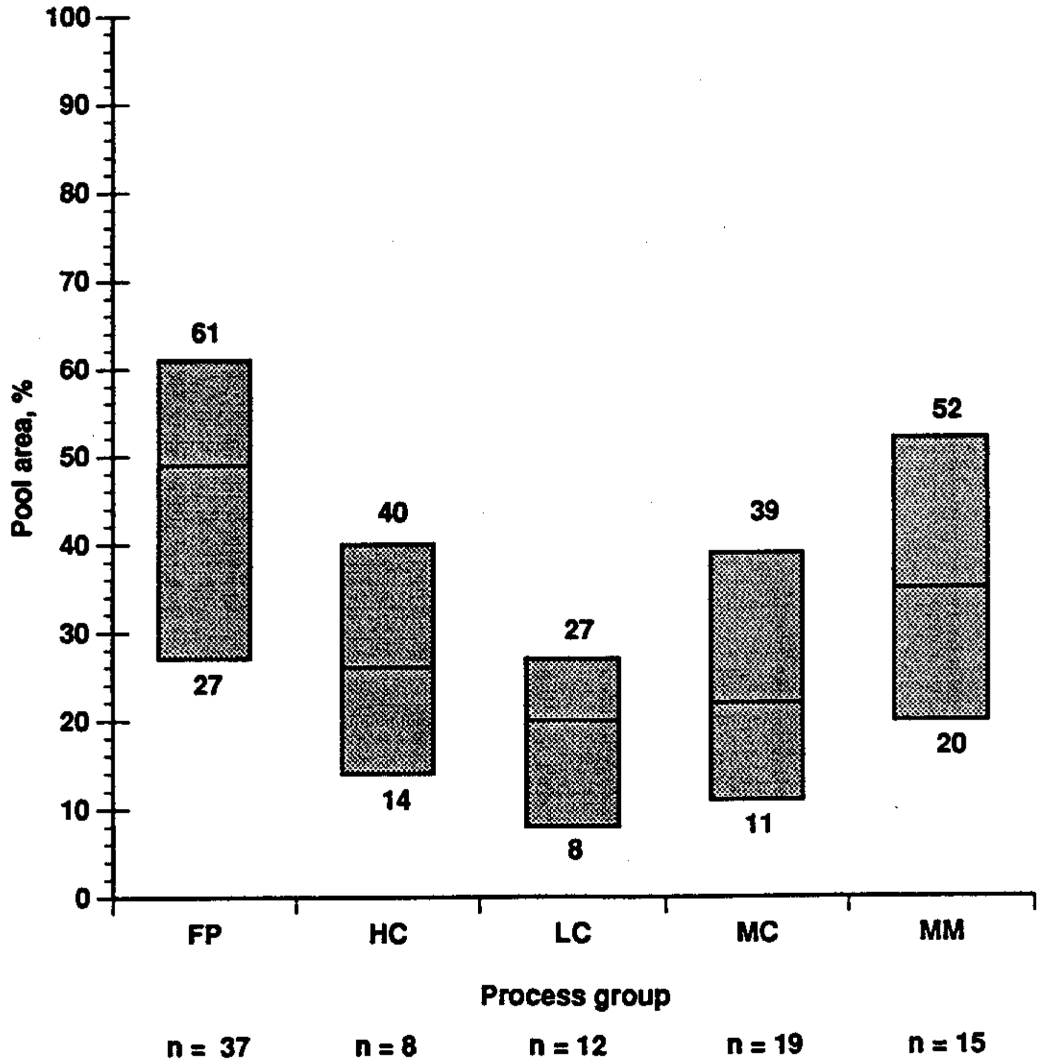


Figure 1D--Tongass large woody debris habitat objectives, by channel type and stream process group, from basin-wide survey data (25th, 50th, 75th percentiles)

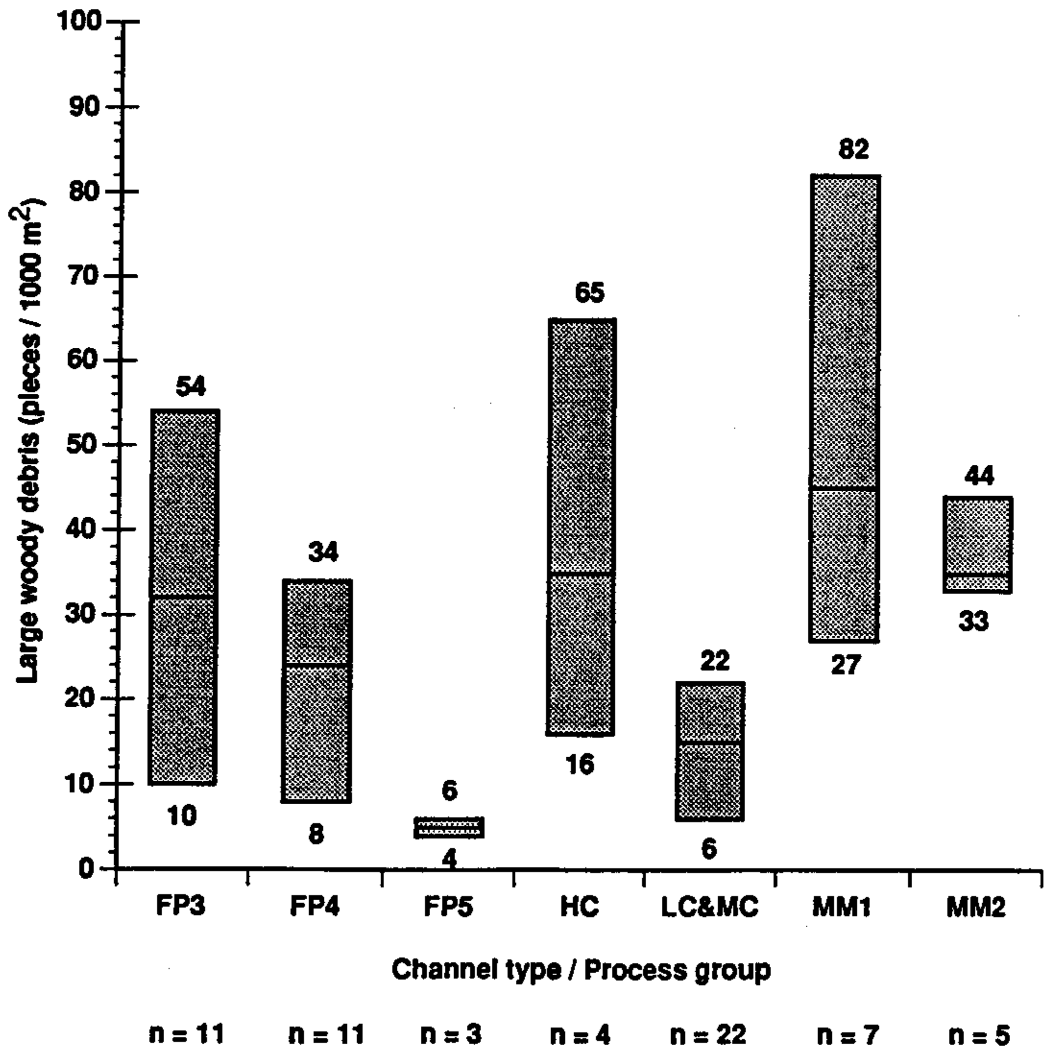


Figure 1E--Tongass stream width-to-depth ratio habitat objectives, by channel type, from channel-type verification survey data (25th, 50th, 75th percentiles)

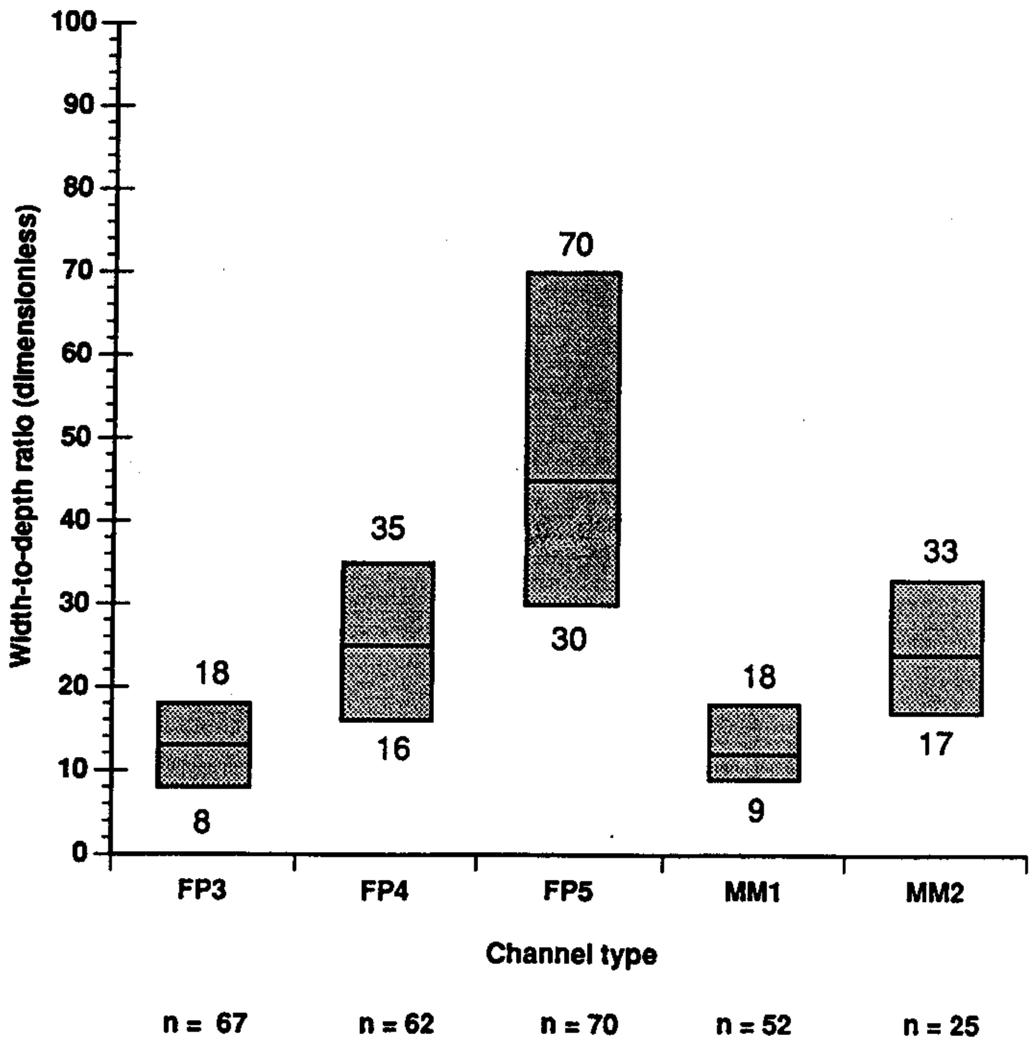
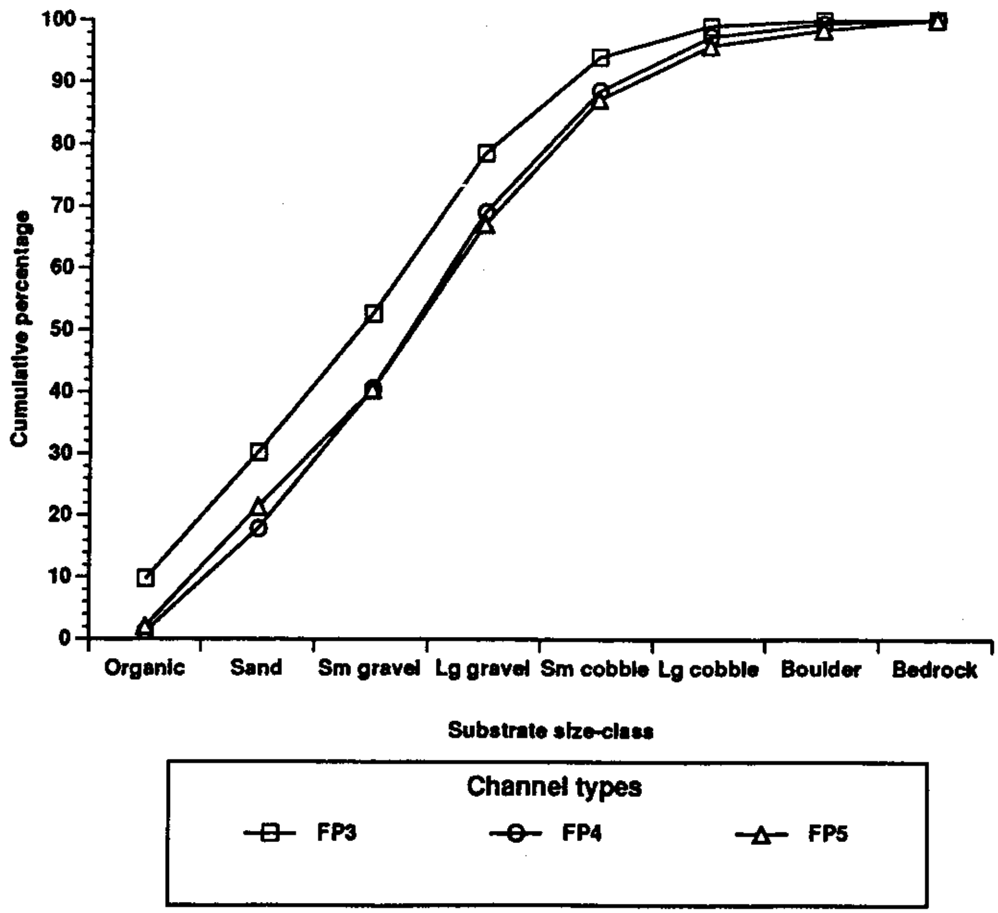
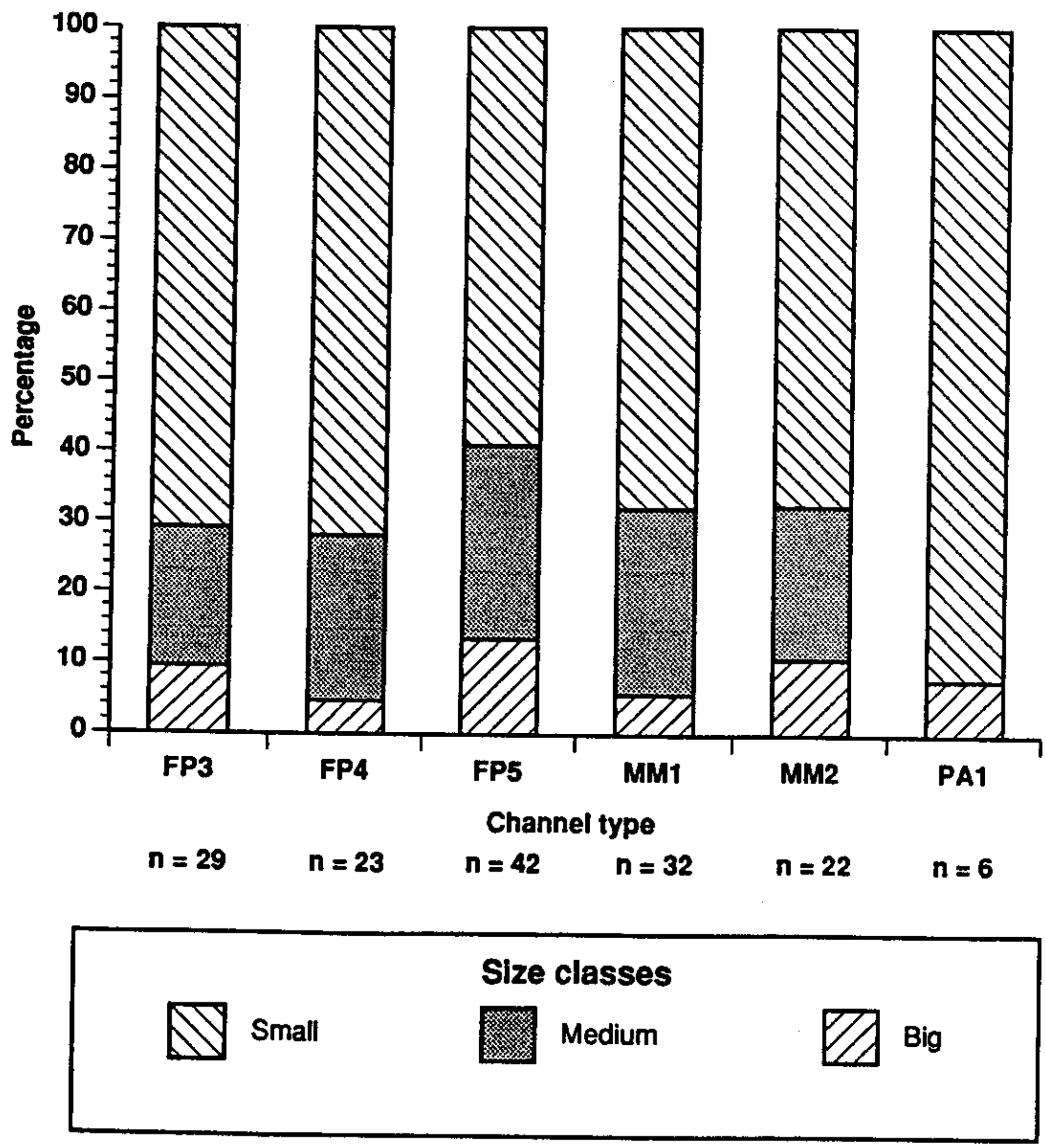


Figure 1F--Substrate particle size-distribution for flood-plain channel types, from channel-type verification survey data



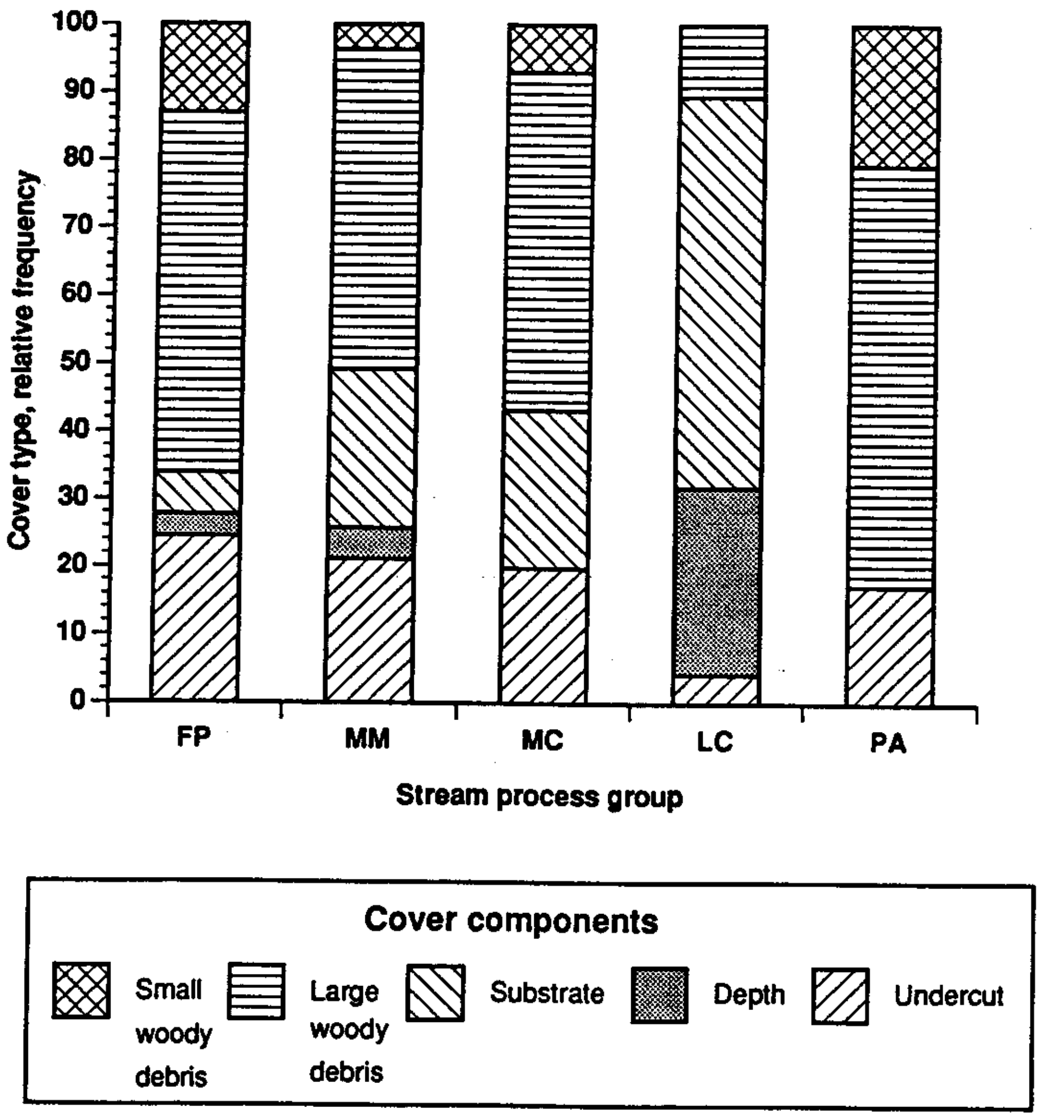
Substrate size classes are: organic/silt, <0.005 cm; sand, 0.005-.4 cm; small gravel, 0.4-2.5 cm; large gravel, 2.6-6.3 cm; small cobble, 6.4-12.7 cm; large cobble, 12.8-25.4 cm; boulder, 25.5-100 cm; and bedrock, > 100 cm.

Figure 1G--Large woody debris size-class distribution for "wood dependent" channel types, from channel-type verification survey data



Large woody debris size-classes are: small, 1-7.6 m long and 0.1-0.5 m diameter; medium, 1-7.6 m long and 0.5-0.9 m diameter; and big, >7.6 m long.

Figure 1H--Dominant fish-habitat cover components (standardized to 100%[1]) by stream process group, from basin-wide survey data



[1] Data represent the relative frequency that various cover components were observed to be the dominant habitat cover.

Third, difficulty in reproducing results of basin-wide survey data is also a concern. No quantitative definition of a pool was used during these surveys: consequently, identifying pools was highly subjective. Comparisons of surveys conducted on the same portion of stream have found that different crews record different results. For example, a repeat survey of a specific reach (600 meters long), using identical basin-wide protocols, found half as many pools during the second survey (K. Coghill 1993, unpublished data). Part of the difference could have been due to a change in water level, which had dropped in the 5 weeks between surveys. We have no way to determine whether the stream surveys used in the analysis presented here were performed at moderate or low water levels, and they likely represent a range of flows. Similarly, pool area estimates depend on water level and are subject to a relatively high degree of observer bias (Overton et al. 1993). Pool depth parameters are generally accepted as the most precise and most sensitive indicator of increased sediment; however, pool depth (normalized for water level) measurements are not found in the existing stream survey data.

Fourth, differences in survey objectives, and the experience and training of the people conducting the surveys, are also expected to cause differences in identifying, counting, and measuring habitat types in the various surveys used in this analysis. Many partial stream-network surveys performed by the Ranger Districts were associated with design of enhancement projects, but PNW Research Station surveys were conducted more comprehensively as part of larger research projects. Consequently, the surveys identified different size-classes for substrate and large woody debris counts, and cover categories were not always consistent. On some of the Ranger Districts, surveys were done by summer seasonal employees who were not available for questioning about exact survey procedures that were implemented.

Interim Tongass habitat objectives were derived specifically for use in the pilot watershed assessments. They were found to be useful indices for assessing fish habitat condition in this application. Because of the limited sample size, however, the data may not accurately represent the true range of habitat characteristics for pristine watersheds in the Tongass. We believe that the stream width-to-depth habitat objective is the most accurate because it uses a standardized sampling procedure and a relatively large number of sample sites. The large woody debris and pool objectives are both limited by small data sets. Of the two sets of interim objectives, large woody debris values should be given the most credence because they are less susceptible to observer bias. Caution should be used in applying these objectives for other purposes until additional data are gathered and analyzed.

Fish Habitat Objectives Applications and Interpretation

Proper application of these habitat objectives require that key habitat attributes for the stream being assessed are collected consistently, and that long segments of stream (hundreds of meters long) be surveyed. Stratifying major geomorphic and riparian vegetation attributes must be adequately accounted for by using the channel-type classification in the survey design. Established channel-type verification and basin-wide habitat survey protocols should be followed (appendix 3).

In habitat surveys for watershed analysis, for one or more habitat indices to fall outside of the established objective range may not be unusual. Using other available information and best professional judgment is essential then, to establish whether these results are likely caused by natural variability or management-related disturbances. Most emphasis should be placed on conditions where watershed analysis results indicate low numbers of pools, few pieces of large woody debris, and high width-to-depth ratios.

Habitat objectives for a given stream segment should be evaluated in the context of measurements from several other segments within the subwatershed and watershed being analyzed. Limited weight should be given to habitat information from a single stream segment. When several segments deviate from the management objective, documenting these conditions and evaluating controlling factors or disturbance mechanisms that may be responsible is important. So is noting if several channel segments have conditions that fall within the range of values for the management objective but are consistently below the 50th percentile value. These results may indicate a declining trend in habitat condition or lack of habitat diversity in the watershed. (See tables 1D and 1E for additional guidelines for interpreting values for specific management objective attributes.)

Stream segments with very good conditions, as indicated by pool area and large woody debris values that exceed the 75th management-objective percentiles, should be noted as key riparian habitat areas. Where large woody debris accumulation greatly exceeds the management-objective standards, documenting potential adverse effects, if any, on channel stability and long-term recruitment of large woody debris from adjacent riparian areas is important.

Another aspect to consider in interpreting stream habitat measurements is the interrelation between attributes. For example, pools are often associated with large woody debris accumulations in alluvial channels. Consequently, the amount of pool habitat and amount of large woody debris should usually be positively correlated. Similarly, a flood plain channel segment with high width-to-depth values is likely to have proportionately less pool habitat (because of areas of bedload sediment aggradation) than a similar channel-type segment where sediment load and transport capacity are more in equilibrium, as indicated by a relatively low width-to-depth ratio.

Implementation Guidelines

Following are some general analysis and reporting guidelines for project-scale watershed habitat-condition analyses:

- Summarize results of stream-condition surveys by subwatershed and watershed cataloging units. Assess the fit of habitat objectives relative to ecological capacities and disturbance regimes of these areas.
- Evaluate these objectives for individual channel-type stream segments, specifically those segments identified as key habitat and those segments most likely to have been influenced by management activities.
- Identify responsible factors or suspected factors influencing fish habitat conditions in the watershed.
- Highlight areas with poor habitat conditions and determine the need for rehabilitation.
- Highlight areas with exceptional habitat condition that warrant special consideration.
- Revise habitat objectives if needed to better reflect the ecological potential of a specific watershed. Revisions should be documented, along with supporting rationale.

RECOMMENDATIONS

The draft Tongass fish habitat objectives should be considered a starting point for developing quantifiable indices to assess and monitor aquatic habitat condition. Several limitations to the data base used to develop the habitat objectives have been discussed. Consequently, users should exercise judgment in drawing conclusions from these data.

Deficiencies in fish habitat information are not unique problems to the Tongass. Lack of comprehensive, accurate, baseline aquatic habitat data is also a major concern for implementing

Table 1D--Interpreting values for fish habitat management objectives for large woody debris and pool data.

Pool and large woody debris percentile values[1]	Interpretations	Recommendations
< 25th	Indicates poor habitat	Initiate detailed cause/effect analysis.
>25th and <50th	Below average habitat	Evaluate with other management objectives to determine degree of concern. Multiple management objectives in this category require detailed cause/effect analysis.
>50th and <75th	Above average, good habitat	Analysis needs to consider past surveys and other analyses to evaluate trend and potential effects from natural disturbance.
>75th	Excellent habitat	Consider past surveys and evaluate trend.

[1] Represents forested riparian habitats.

the FEMAT watershed analyses in the Pacific Northwest. The Tongass has two major advantages over other Northwest Forests for future development and improvement of fish habitat objectives. First, the Tongass has many relatively pristine watersheds where natural ecological processes can be measured and used as a reference for evaluating conditions in managed watersheds. Second, the Tongass has a relatively consistent and comprehensive framework for stratifying watersheds and the component parts of the drainage networks in these watersheds. This framework greatly enhances our ability to extrapolate inventory and monitoring data between watersheds. With this background in mind, the following measures are recommended to update and improve draft Tongass fish habitat objectives:

- Standardized stream-survey data-collection and management procedures need to be adopted by all Forest units and the Juneau Forestry Sciences Laboratory. The pilot watershed-analysis protocols (appendix 3) provide a good basis for developing a stream-survey handbook for the Tongass. A comprehensive regional training program developed in partnership with the Juneau Forestry Sciences Laboratory for stream and riparian habitat survey and monitoring protocols is needed.

- The Tongass should move forward aggressively to fill stream-survey data gaps. The geographic representation of baseline stream habitat data needs to be expanded. Several channel types have no or little information for key habitat attributes. Future plans for basin-wide stream surveys and channel-type mapping updates need to take these information needs into account.

Table 1E--Interpreting values for fish habitat management objectives for most-sensitive channel types (FP and MM process groups) for width-to-depth ratio data.

Width/depth percentile values	Interpretations	Recommendations
>75th	Indicates poor habitat	Initiate detailed cause/effect analysis
>50th and <75th, or <25th	Below average habitat	Evaluate with other management objectives to determine degree of concern. Multiple management objectives in this category require detailed cause/effect analysis.
>25th and <50th	Above average, good habitat	Analysis needs to consider past surveys and other analyses to evaluate trend and potential effects from human-caused and other natural disturbance.

- The Tongass should establish a broad regional network of reference stream segments in both pristine and managed watersheds to assess long-term trends in riparian and fish habitat conditions. Research Natural Areas and Wilderness Areas have the best potential as control sites to compare condition trends between undisturbed and managed watersheds in the long term.

- The current list of fish habitat objectives should be revised and expanded as more information becomes available. We recognize that substrate size-distribution in flood-plain channels is strongly influenced by bedrock geology and local erosion processes. We therefore recommend further assessment of substrate distributions by channel type and stratified by bedrock geology before comprehensive substrate objectives are adopted. In addition, the riffle stability index used in the pilot watershed analyses (appendix 3) should be evaluated further, and techniques for measuring substrate embeddedness should also be tested.

- Pool-depth measurements in existing stream survey data were determined in a variety of ways and are probably not very accurate. Other pool attributes identified for future consideration include maximum pool depth, residual pool depth, mean pool depth, and pool habitat unit (for example, backwater pool) area.

- Finally, habitat objectives for wetted channel width-to-depth ratio, standardized for stream discharge, should also be developed.